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WHALE STRANDINGS IN SOUTH AUSTRALIA (1881–1989)

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Summary

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Cetacean strandings were collated from museum records, and published and unpublished sources. The identification of stranded animals was verified in 85% of events by examination of voucher specimens or photographs. Trends in the stranding record were documented, but reasons for strandings were not investigated in detail. From 1881 to 1989, 309 stranding events, involving 24 species, have been recorded in South Australia, while an additional species may have stranded in the State. Stranding events most commonly involved *Tursiops truncatus, Delphinus delphis, Physeter macrocephalus, Caperea marginata, Mesoplodon layardii, Globicephala melas, Kogia breviceps,* and *Balaenoptera acutorostrata.* Strandings were less frequent on the western shores of Gulf St Vincent and Spencer Gulf, possibly because these are protected from strong southwesterly winds. There was a trend towards more frequent events being recorded in January/February and September/October. Some species showed seasonal trends in stranding, possibly related to their migratory patterns or movements inshore/offshore. Eighty-nine percent of stranding events involved single animals; 18% involved groups of two or three animals and 3% were of four or more. Twenty-eight percent of stranded animals were juveniles. In some species (e.g. *Balaenoptera acutorostrata, Caperea marginata, Globicephala* spp., *Kogia* spp. and other Balaenopteridae), juveniles constituted a high proportion (>30%). At least 15% of stranding events involved live animals, although more accurate observations and reporting in recent times indicate that live strandings are probably more frequent. There were live strandings of 16 species, including baleen and toothed whales. There was a tendency for large whales to strand more often in a moribund or decaying state than small species. On average, about 20 recorded stranding events have occurred in South Australia each year since 1985.

KEY WORDS: cetaceans, stranding, mass stranding, trends, South Australia

Introduction

Cetacean strandings have captured the attention of humans since Aristotle's time (see Aristotle 335 BC), but only in the last few decades have these events been studied in detail. More recently, trends have been analysed and plausible hypotheses proposed on the possible causes for stranding of live animals (reviewed by Geraci & St Aubin 1979).

There are many possible causes of cetacean strandings, e.g. disease, injury (both natural and anthropogenic), birth difficulties, adverse weather, parasite infections, food supply, old age and toxic pollutants (Geraci & St Aubin 1979). A recent hypothesis suggests that cetaceans may 'make navigational mistakes' if the earth's geomagnetic field is disturbed (Klinowska 1986). Sergeant (1982) concluded that nearly all animals involved in single strandings were diseased or parasitised, but those involved in mass strandings were not.

In Australia, the most detailed accounts of cetacean strandings exist for Tasmania (reviewed by Nicol & Croome 1988). Some published observations are available for Victoria (Wakefield 1967; Warneke 1983, 1988) and the Illawarra district of New South Wales (Robinson 1984). Species recorded in Queensland are discussed in Bryden (1978), Paterson (1986) and Paterson & Van Dyck (1990). Since 1984 all states, but not the Northern Territory, have been reporting strandings to the Australian National Parks & Wildlife Service.

The South Australian Museum has taken a special interest in cetaceans since the mid- to late 1800s (Hale 1956). E. R. Waite, H. M. Hale and, more recently, P. F. Aitken established a stranding reporting and collecting network which provided us with sufficient records to analyse trends. Aitken (1971) published a summary of the 18 species which he regarded as occurring in South Australia, based on strandings or sightings (also summarised by Sergeant 1982). A revised account was presented by Ling & Aitken (1981). Stopp (1984)† compiled a detailed account of the locations of many South Australian strandings up to 1984, with some other details for each specimen.

Here we summarise the entire stranding record for South Australia. Trends in strandings are analysed in relation to species composition and abundance, geographic and seasonal distribution, group size of stranded animals, age, and active *vs* passive stranding events. No attempt has been made to investigate or explain the cause of strandings,

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† Stopp, B. A. (1984) Cetacean strandings in South Australia 1881–1984. Field Study for Associate Diploma in Wildlife and Park Management, South Australian College of Advanced Education.

except in very general terms. Special attention was paid to the possible influences of the unique oceanographic conditions of South Australia on the cetaceans of southern Australian waters.

Oceanography of the South Australian Coast

The South Australian coast measures approximately 4000 km of which about 1500 km (38%) border two large gulfs, St Vincent and Spencer. Several large bays occur along the seaward coast. The 200-m bathometric contour lies 100–200 km offshore for much of the coast but is closer inshore (50 km) in the southeast of the State. Hence there is a broad continental shelf which, with the exception of Bass Strait, is unique for the southern half of the continent. Deep canyons are found to the southeast of Kangaroo Island and southwest of Ceduna. Annual mean water temperatures in non-gulf waters vary from 15° – 18°C (Radok 1976). Cold oceanic currents generally flow in an easterly direction across southern Australia at rates of 14–25 km per day, except in summer when a westerly eddy is found in the Great Australian Bight region (Federal Department of Transport 1987). A fast (35 km per day) easterly current occurs in the Bight during winter. The Leeuwin current, which originates in the Indian Ocean off Western Australia, brings warm water into the Bight in autumn and winter (Pearce & Cresswell 1985). A surface temperature gradient of up to 5°C may be noted along the southern coast of Western Australia at this time. Little has been documented on gulf and inshore currents in South Australia although studies are in progress (P. Petrusevics pers. comm. 1990).

In South Australia, the prevailing winds are generally southerly or southeasterly in summer and southwesterly or northerly in winter (Climatic Atlas of Australia 1988). There may be some deviation from this pattern in the region of the gulfs. Wind-induced upwelling events are important in the southeast of the State in summer (Lewis 1981; Schahinger 1987). Other areas of upwelling are found off the southwest coast of Kangaroo Island, and between Coffin Bay and Anxious Bay (just south of Streaky Bay) (P. Petrusevics pers. comm. 1990).

Bye (1976) described the gulfs (Spencer Gulf and Gulf St Vincent, separated by Yorke Peninsula) and their associated waters (Investigator Strait and Encounter Bay) as a complex zone of fundamental importance to South Australia's marine environment. (Investigator Strait (north of Kangaroo Island) and Encounter Bay (east of Kangaroo Island) are not considered part of the gulfs, because they are very much influenced by oceanic patterns). Salinity at the head of the gulfs is much higher than at their mouths (for Spencer Gulf as high as 48‰ in the late summer and about 43‰ in late winter (Nunes & Lennon 1986)). Due to the shallowness of the water in the gulfs (< 50 m), temperatures range from about 12°C in winter to about 24° in summer (Bye 1976; Nunes & Lennon 1986). Again, there is a north-south gradient. The gulfs are somewhat protected from the full effects of the Southern Ocean by their surrounding land masses.

Another area of interest oceanographically, but about which little is known, is the Head of the Great Australian Bight. In winter, temperatures and salinities are higher than the water to the south (Pearce & Cresswell 1985).

Materials and Methods

Information on cetacean strandings was gathered from specimens and photographs held in the collections of the South Australian Museum; published records in Aitken (1971), Hale (1931, 1939, 1959, 1962), Ling & Aitken (1981), Stopp (1984), Waite (1919), and newspaper articles; and unpublished records from various sources. No specimens from South Australia exist in the collections of the Western Australian Museum, Australian Museum, or Museum of Victoria. The identifications of all specimens in the South Australian Museum have recently been verified; hence some published observations (e.g. Aitken 1971) may not be consistent with ours. Of the 309 stranding events reported here, 75% are verified with voucher specimens in the South Australian Museum and 10% are verified with photographs alone.

The taxonomy used here is that of Bannister (1988) with the exception of *Globicephala melas* (= *melaena*) (Rice 1989), the placement of *Caperea marginata* in the family Neobalaenidae (Barnes & McLeod 1984) and the use of the specific name *macrocephalus*, not *catodon*, for *Physeter* (see Rice 1989).

A 'stranding', in the present study, is any event involving the beaching or washing up on shore of live or dead cetaceans, as well as observations of dead cetaceans floating offshore. Skeletal material from the coast is included in our definition of stranding (but not dated), except in the case of *Eubalaena australis* near old whaling stations. It is assumed that most museum specimens lacking data were collected as a result of stranding events, although caution was exercised in the cases of *Physeter macrocephalus* and *Eubalaena australis*

due to whaling activities. It is possible that some small cetaceans could have been caught accidentally in fishing nets, but this information is not recorded by the Museum. A single *Caperea marginata* (Encounter Bay, September 1887) was caught in a fishing net.

The relative age of individuals was estimated only in those cases where the total length of the animal was known or, in a few cases, was estimated from photographs. Neonates were defined as individuals approximately the length of newborn animals, based on information from other studies (Perrin *et al.* 1984; Ross 1984). Juveniles were defined as being less than, or equal to, a certain proportion of the species' length at physical maturity. These are: 50% (*E. australis, P. macrocephalus, Globicephala* spp., *Grampus griseus*), 55% (*C. marginata*), 60% (Balaenopteridae, *Tursiops truncatus, Delphinus delphis*), 65% (*Kogia* spp.) and 70% (Ziphiidae). These proportions were based on information from several sources (Bryden 1972; Ross 1984; Mead & Potter 1990; Ross pers. comm. 1990).

Where the actual date of stranding was unknown, the month was estimated on the basis of photographs of the animal or a description of its state of decomposition.

The term 'gulfs' refers here only to Gulf St Vincent and Spencer Gulf. The term 'gulfs region' includes Investigator Strait and Backstairs Passage and the north coast of Kangaroo Island.

Results

Species

Twenty-four species of cetaceans were verified as having stranded along the South Australian coast between 1881 and 1989 (Table 1). There is some uncertainty about the additional species, *(Balaenoptera borealis)* which, although in the South Australian Museum collections, may not have stranded in the State. Recent re-examination of baleen plates (SAM M4829), previously identified as *B. edeni*, resulted in the identification being determined as *B. borealis* (based on characters described by Mead (1977) and Horwood (1987)). However, the plates have no accompanying data and therefore could have been collected elsewhere, or they may not have been from a stranded animal. No species are recorded as stranded in the State based solely on photographs or other reports lacking voucher material (Table 1).

In terms of individuals (but excepting the mass strandings of *Pseudorca crassidens*), the most commonly stranded species were the dolphins, *T. truncatus* and *D. delphis*. These are followed by six species: *Physeter macrocephalus, Caperea marginata, Mesoplodon layardii, Kogia breviceps, Globicephala melas* and *Balaenoptera acutorostrata*, whose status varies depending on whether specimen records lacking vouchers or locality information are included. All have greater than 10 recorded stranding events. *Balaenoptera physalus, Berardius arnuxii* and *Kogia simus* have stranded only once. There is some uncertainty about whether *Tasmacetus shepherdi* has stranded once or twice (G. Ross pers. comm. 1990).

Geographic distribution of stranding events

Stranding events having geographic locality information (238) were not evenly distributed along the South Australian coast (Fig. 1). More strandings occurred in (or were reported from) the Coffin Bay/Port Lincoln and Coorong regions, followed by the eastern side of Gulf St Vincent, the north coast of Kangaroo Island and the Streaky Bay/Ceduna regions. Very few strandings were reported from the western sides of Gulf St Vincent and Spencer Gulf, despite moderate levels of human activity along these coasts. There were few strandings reported in the far west of the State, much of which is lined with inaccessible cliffs and a rocky shore. Forty-six percent of strandings occurred within the gulfs region which includes about 40% of the South Australian coast.

Mass strandings (i.e. more than three individuals) have occurred at six locations (Fig. 1). Five were in the gulfs region. Three locations (north of Adelaide and northeastern Kangaroo Island) were where other live strandings have occurred (Fig. 2).

Active (= live) strandings have been reported less frequently in remote areas than around centres of population, e.g. in the gulfs region (Fig. 2). Nevertheless, it appears that some areas (e.g. Port Lincoln/Coffin Bay, Nepean Bay, eastern Gulf St Vincent, Murray River mouth) are more prone to active strandings than are others.

There are trends in the geographic distribution of stranding events of species or species groups (Figs 3–8). Both *T. truncatus* and *D. delphis* have stranded along much of the coast but concentrations of events exists around Adelaide, Port Lincoln, Nepean Bay and the Murray River mouth (Fig. 3). The two records of *T. truncatus* from Lake Alexandrina (north of the Coorong) were made before the barrages were built in the 1930s. Few dolphin strandings have been recorded from the northern ends of the gulfs. Of the 36 strandings within the gulfs region, more were of *T. truncatus* than *D. delphis* ($P < 0.10$, χ^2 2.78, 1 d.f.).

Few strandings of *Globicephala macrorhynchus* and *G. melas* were reported in the gulfs region (Fig. 4). The only two records within the gulfs proper being *G. macrorhynchus*, one of these a mass stranding.

TABLE 1. *Stranded cetaceans along the South Australian coast recorded from various sources. South Australian Museum (SAM) specimens with no locality data are in parentheses and are included in the total numbers to their left. Events from other sources includes photographs, published and unpublished records. Total individuals includes specimens plus individuals from other sources. Unidentified records not listed.*

Family, genus & species	SAM specimens	Events from other sources	Total individuals	Total events
BALAENIDAE				
Eubalaena australis	7(5)	0	7	7
NEOBALAENIDAE				
Caperea marginata	27(8)	2	29	29
BALAENOPTERIDAE				
Balaenoptera acutorostrata	11(2)	1	12	12
*B. borealis**	1(1)	0	1	1?
B. edeni	6(0)	1?	6	6
B. musculus	5(1)	0	5	5
B. physalus	1(0)	0	1	1
Megaptera novaeanghiae	4(0)	1	5	5
DELPHINIDAE				
Delphinus delphis	39(12)	16	60	54
Globicephala sp.	0	2	2	2
G. macrorhynchus	10(1)	0	10	6
G. melas	11(1)	4	15	14
Grampus griseus	2(0)	2	4	4
Orcinus orca	3(1)	0	3	3
Pseudorca crassidens	2(0)	0	*c* 310	2
Tursiops truncatus	71(21)	12	126	65
PHYSETERIDAE				
Kogia breviceps	20(1)	1	22	13
K. simus	1(0)	0	2	1
Physeter macrocephalus	26(4)	8	34	34
ZIPHIIDAE				
Berardius arnuxii	1(0)	0	1	1
Hyperoodon planifrons	7(0)	0	7	7
Mesoplodon sp.	0	5	6	5
M. bowdoini	2(0)	0	2	2
M. grayi	8(0)	0	8	8
M. layardii	22(0)	1	24	19
Tasmacetus shepherdi	1(0)	0	1	1
Ziphius cavirostris	2(0)	0	2	2
TOTALS	290(58)	56	705	309

* Doubtful S.A. record

Strandings of *C. marginata* have been reported from the Victorian border to Streaky Bay (Fig. 5) although the latter location is unsubstantiated. Sixty-five percent of strandings have occurred in the Port Lincoln and Nepean Bay areas. No strandings have been recorded from well within the gulfs.

Balaenopterids show some interesting trends (Fig. 6). *B. edeni*, with the exception of a dubiously identified specimen from Cape Banks (approx. 38°S), has always stranded well within the gulfs. *B. acutorostrata*, on the other hand, has almost always stranded outside the gulfs and usually in specific areas (e.g. Coffin Bay, Port Lincoln, Nepean Bay and the Coorong). No trends were apparent for other species. The single stranding of a juvenile *B. physalus* occurred at the northern end of Gulf St Vincent.

The numerous strandings of *Physeter macrocephalus* have occurred along almost the entire South Australian coast (Fig. 7). Few have been recorded within the gulfs. The record from Adelaide was a specimen of bones of unknown date, buried in sand in shallow water. No record could be found of a large whale stranding near Adelaide in the past 50 years, so we assume that these bones represent an older stranding event. *Kogia breviceps* has also

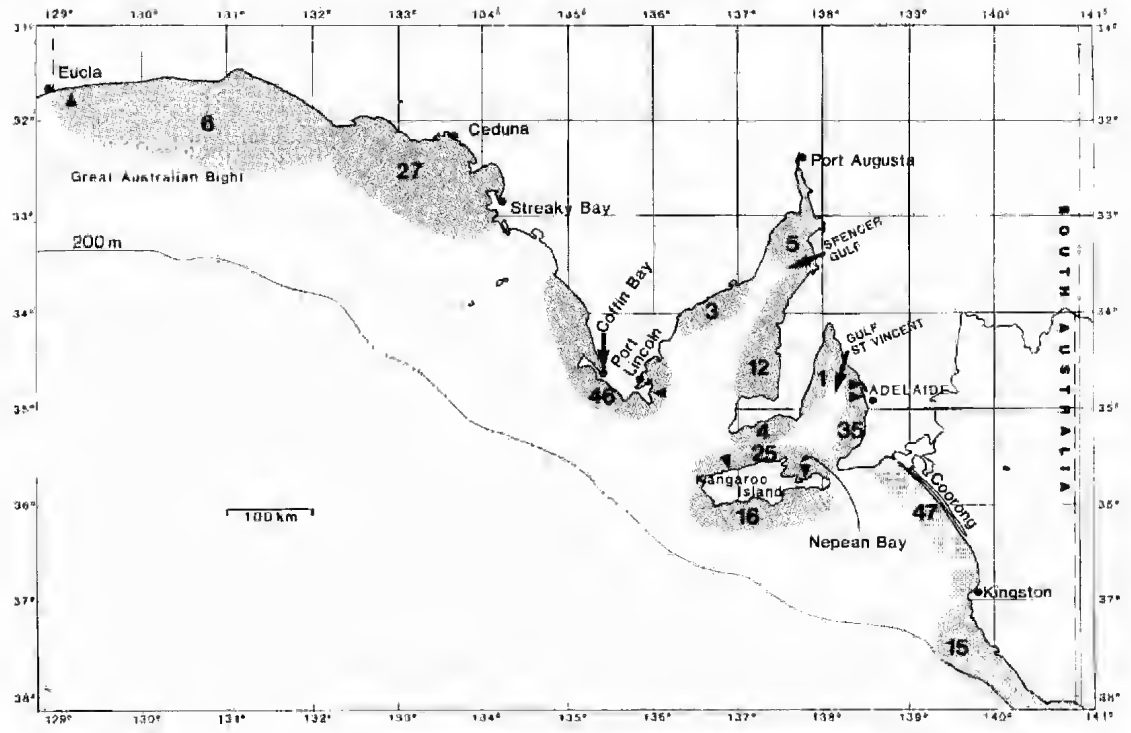

Fig. 1. Geographic distribution and number of reported stranding events in South Australia, 1881–1989. Shaded areas indicate coastline over which events took place. Solid triangles denote mass stranding localities.

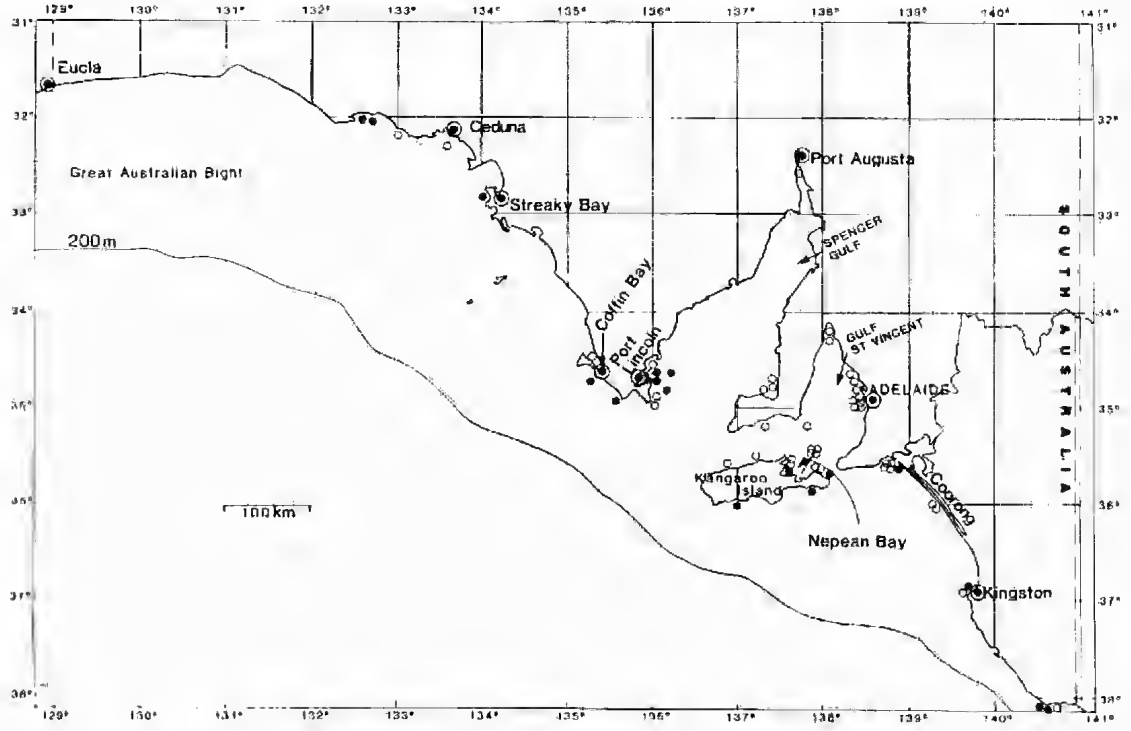

Fig. 2. Geographic distribution of reported active (○) and passive (●) stranding events in South Australia, 1881–1989.

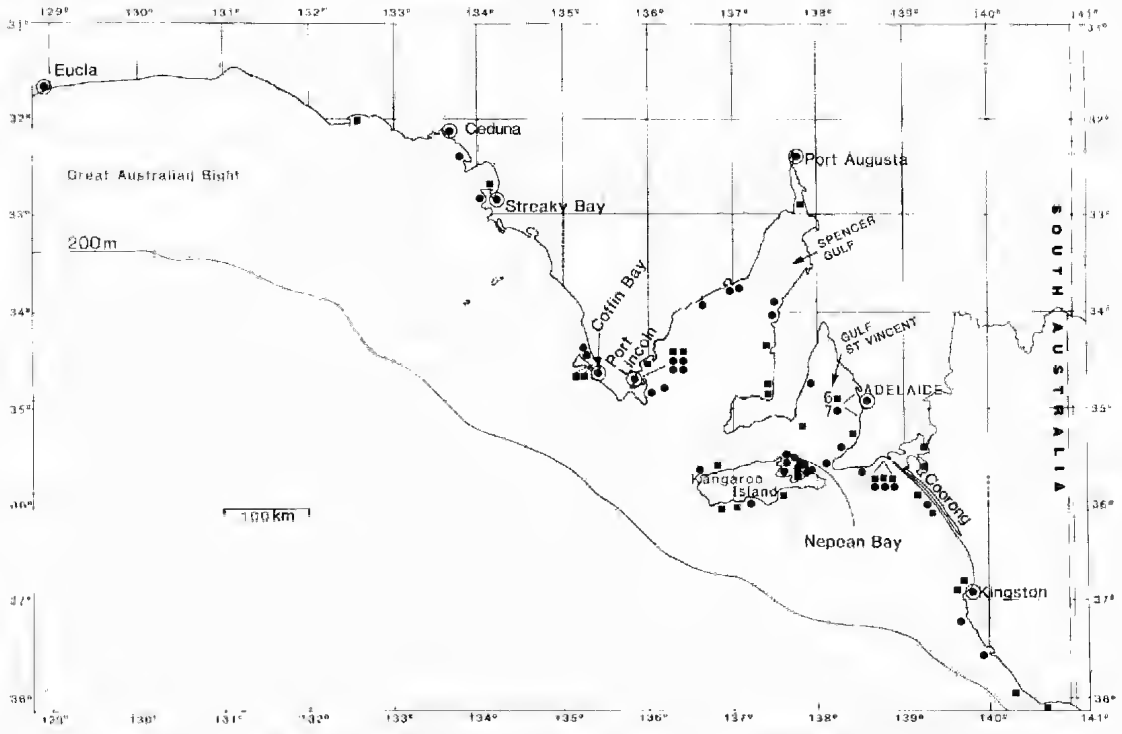

Fig. 3. Geographic distribution of reported dolphin strandings in South Australia, 1881–1989. Each symbol represents a *Delphinus delphis* (●) or *Tursiops truncatus* (■) stranding event.

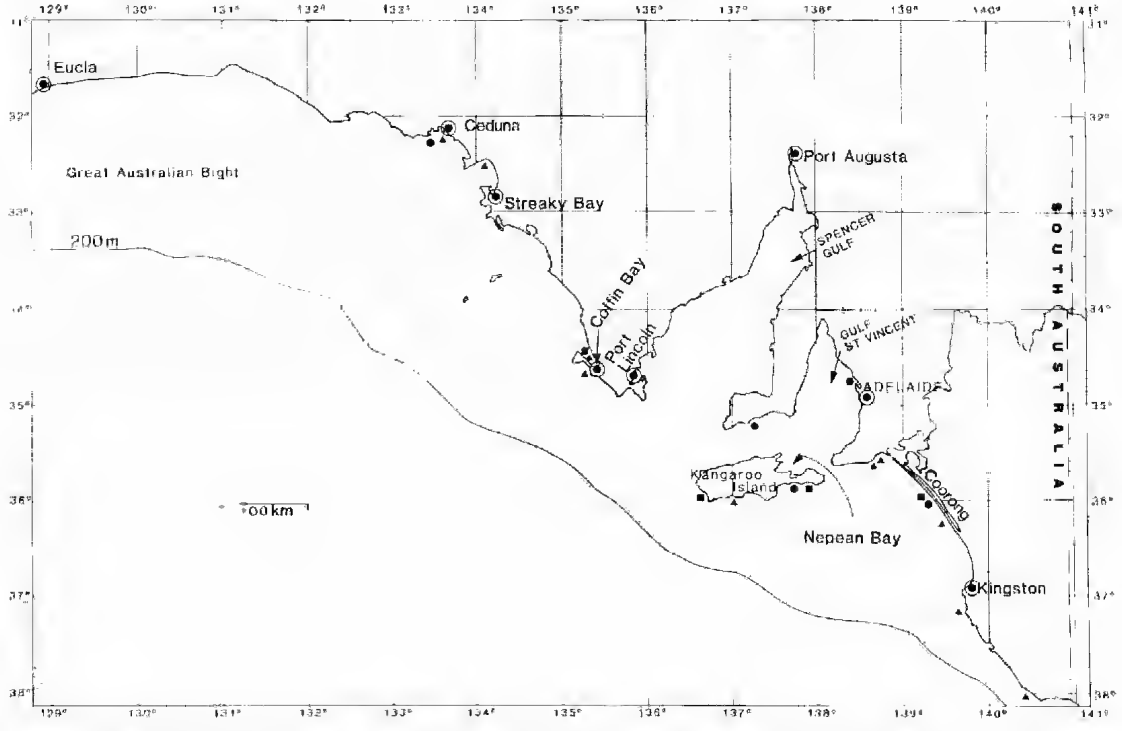

Fig. 4. Geographic distribution of reported pilot whale strandings in South Australia, 1881–1989. Each symbol represents a *Globicephala macrorhynchus* (●), *G. melas* (▲) or *Globicephala* sp. (■) stranding event.

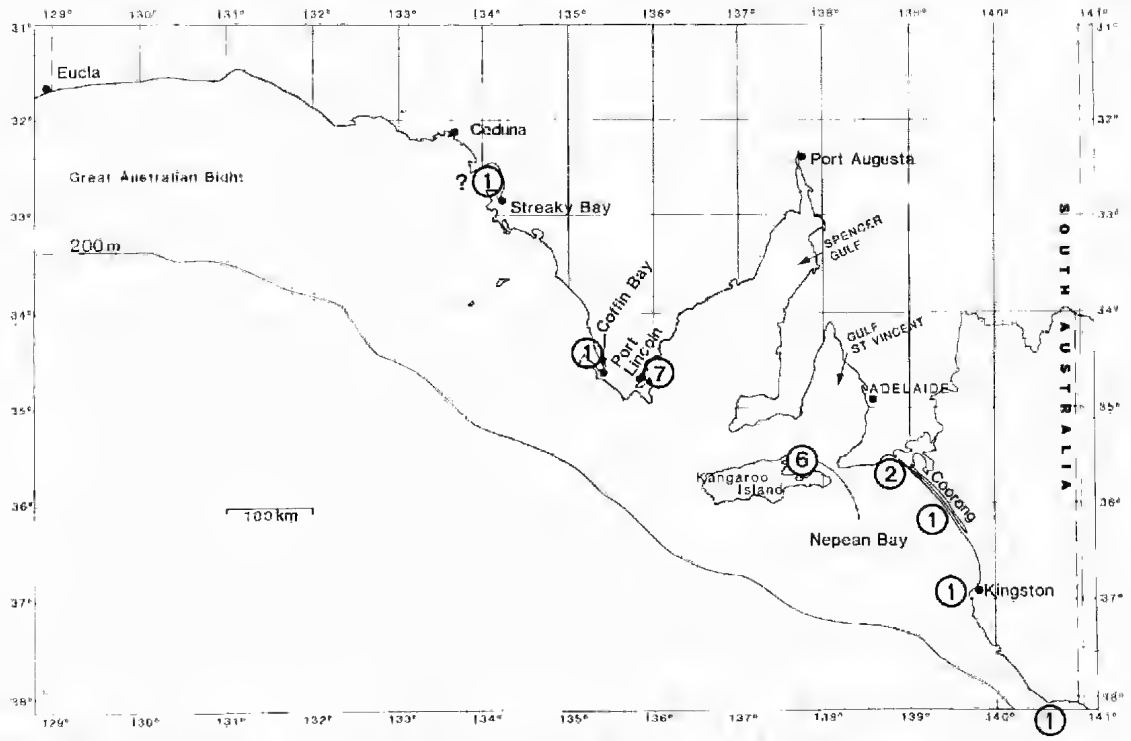

Fig. 5. Geographic distribution of reported strandings of *Caperea marginata* in South Australia, 1881–1989. Numbers in circles represent numbers of events. Streaky Bay stranding is unsubstantiated.

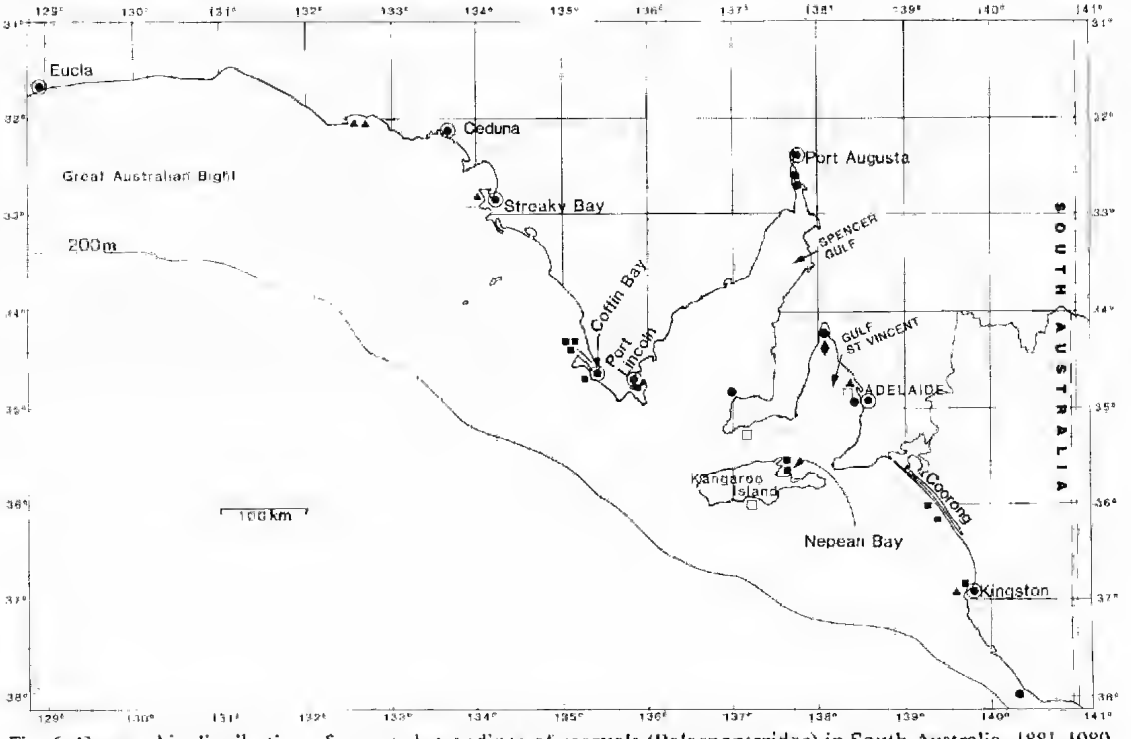

Fig. 6. Geographic distribution of reported strandings of rorquals (Balaenopteridae) in South Australia, 1881–1989. Each symbol represents a *Balaenoptera edeni* (●), *B. musculus* (▲), *B. acutorostrata* (■), *B. physalus* (♦) or *Megaptera novaeangliae* (□) stranding event.

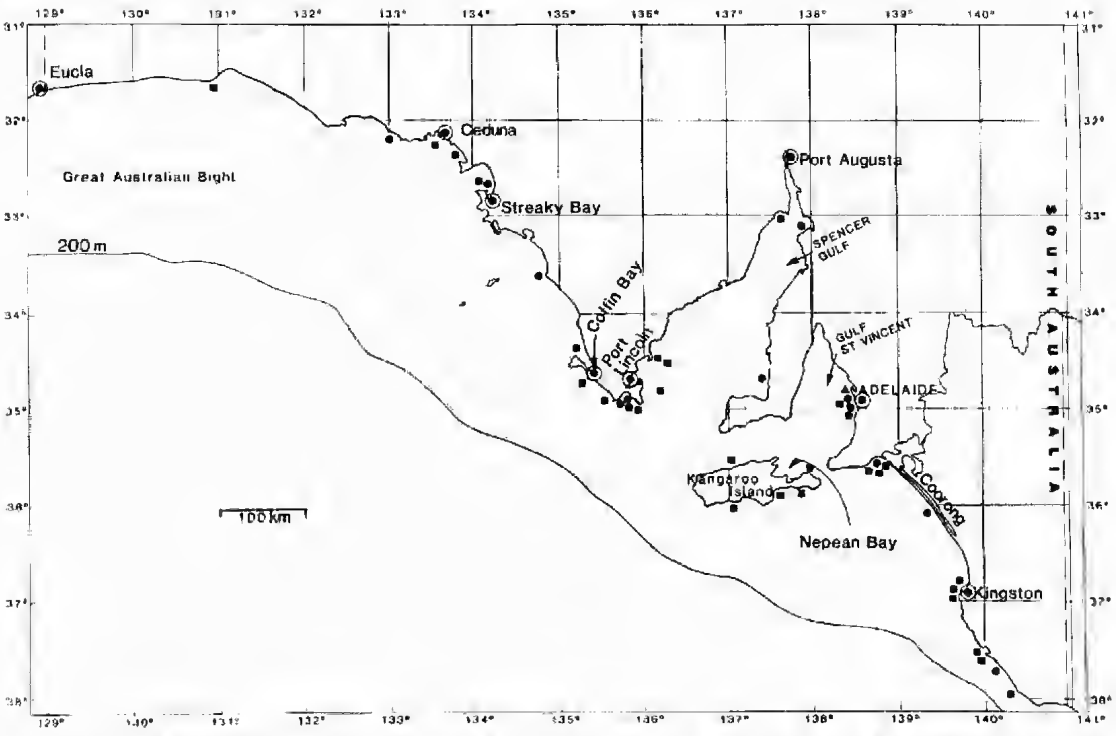

Fig. 7. Geographic distribution of reported strandings of Physeteridae in South Australia, 1881–1989. Each symbol represents a *Kogia simus* (▲), *K. breviceps* (●) or *Physeter macrocephalus* (■) stranding event.

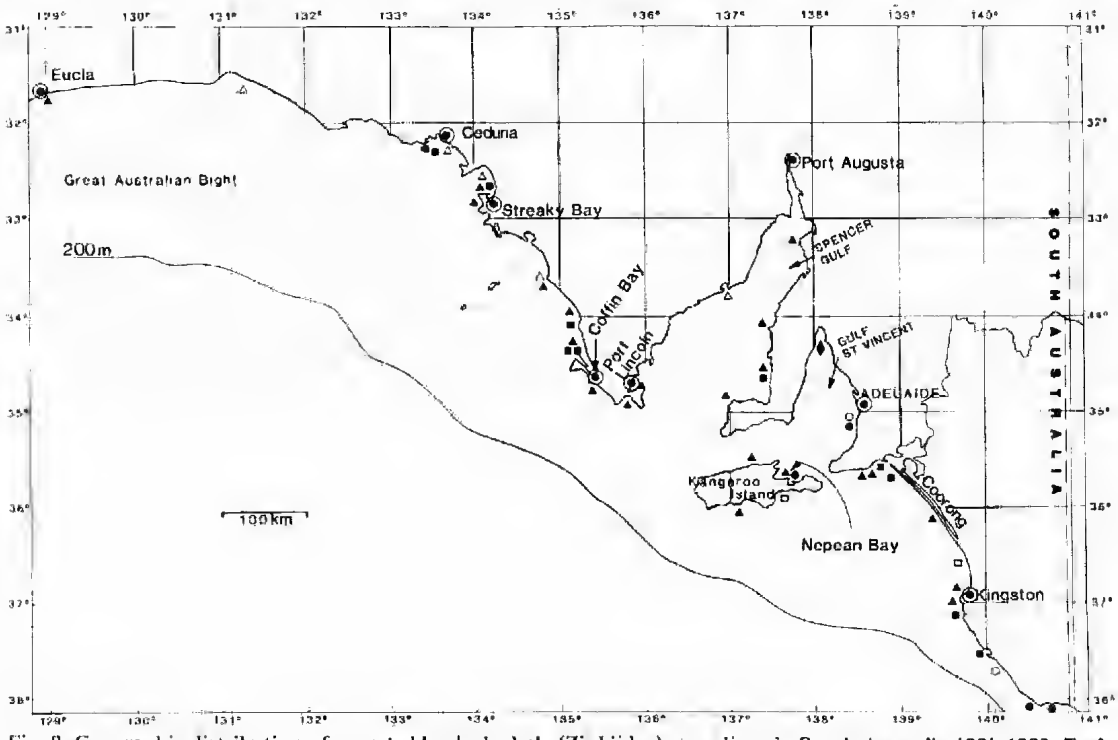

Fig. 8. Geographic distribution of reported beaked whale (Ziphiidae) strandings in South Australia 1881–1989. Each symbol represents a *Berardius arnuxii* (♦), *Ziphius cavirostris* (○), *Hyperoodon planifrons* (■), *Mesoplodon bowdoini* (□), *M. grayi* (●), *M. layardii* (▲), *Mesoplodon* sp. (+) or *Tasmacetus shepherdi* (*) stranding event.

stranded over a wide stretch of the coast, including the gulfs, but none has stranded on Kangaroo Island. The single stranding event of *K. simus* is from Adelaide.

Beaked whale strandings have been recorded along the entire coastline (Fig. 8). Only 25% of the beaked whale stranding events have been within the gulfs region. There are many records from the western side of Eyre Peninsula and along the southeastern coast of the State.

Four species have not been illustrated on the foregoing distribution maps. To our knowledge, *Eubalaena australis* stranded three times during 1881–1990; an adult at Port MacDonnell in the far southeast and two neonates at the Head of the Great Australian Bight. *Grampus griseus* has stranded at four localities: Point Turton (Yorke Peninsula), Coorong, Willson River (Kangaroo Island) and Denial Bay (near Ceduna). The locations of possible *O. orca* strandings have not been reported (see Ling 1991). Mass strandings of *P. crassidens* occurred twice and are discussed under 'Group size of stranded animals'.

Seasonal trends

Stranding events (all species combined) were recorded most frequently in January – April and September – October (Fig. 9). However, this trend does not always extend to individual species, or species groups (Figs 10 and 11). Beaked whale and *T. truncatus* strandings were recorded most often in summer (Fig. 10). An increase in rorqual strandings was evident in September (Fig. 11), with six out of the eight being juvenile animals. We have

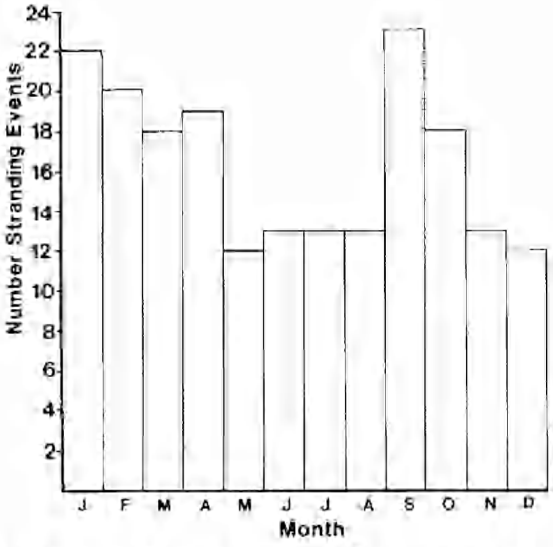

Fig. 9. Month of occurrence of reported stranding events in South Australia, 1881–1989.

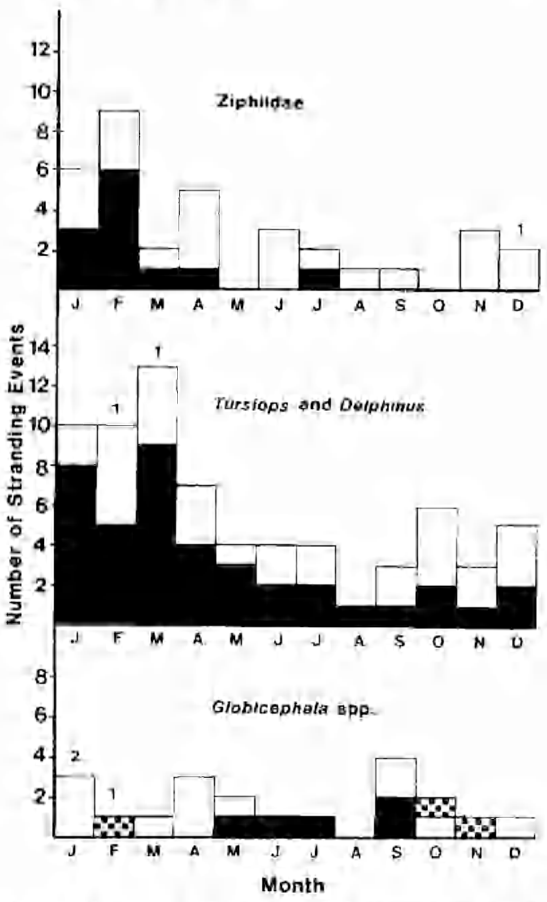

Fig. 10. Month of occurrence of reported stranding events of Ziphiidae, *(Mesoplodon layardii* solid bars), and Delphinidae *(Tursiops truncatus* solid, *Delphinus delphis* open, *G. macrorhynchus* solid, *G. melas*, open, *Globicephala* sp. dotted) in South Australia, 1881–1989. Numbers above bars refer to numbers of neonatal individuals stranded.

insufficient data on other species, or species groups, to draw conclusions, although there did appear to be slight increases during September - October for *Globicephala* spp., *C. marginata* and *T. truncatus*.

Some species appeared to have stranded in specific periods (Figs 10 and 11). *Kogia breviceps* stranded from April to October, mostly between July and October. *Physeter macrocephalus* stranded between July and December. *M. layardii* (January – July) and *G. macrorhynchus* (May – September) have also stranded in somewhat restricted periods, but sample sizes may not be sufficient to be sure of such trends. The stranding of an adult *E. australis* in February is noteworthy, since it is outside the period of sightings of live animals in coastal South Australia and Victoria. The nature of its injuries – almost decapitated (possibly by a large

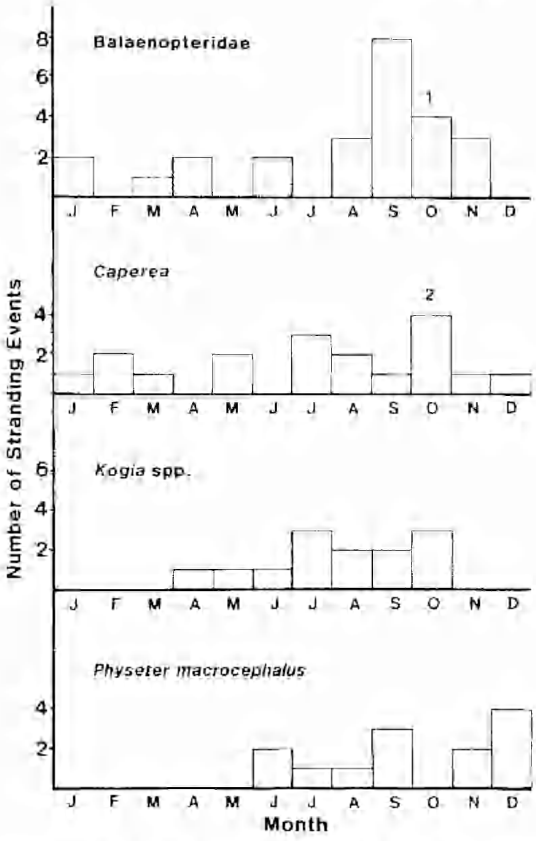

Fig. 11. Month of occurrence of reported stranding events of rorquals (Balaenopteridae), *Caperea marginata*, *Kogia* spp., and *Physeter macrocephalus* in South Australia, 1881–1989. Numbers above bars refer to numbers of neonatal individuals stranded.

ship's propeller) – suggests that it may have died some distance offshore.

Strandings of *T. truncatus* were most frequent in January – March, both within and outside the gulfs (Table 2). Events were recorded throughout the year in both regions, with a possible reduction in July – September outside the gulfs. The pattern for *D. delphis* was similar but there were no strandings recorded in April – June within the gulfs. This could suggest an absence of live *D. delphis* from the gulfs during the autumn quarter.

Group size of stranded animals

There were 184 stranding events involving single animals. Fifteen (8%) events had two or three individuals and six (3%) had five or more (Table 3). When two stranded, most of the events were cow/calf associations, especially *Mesoplodon* spp. and *K. breviceps*. Excluded from Table 3 is a possible association between an adult and subadult male *Hyperoodon planifrons* which stranded 60 km and one day apart.

Mass strandings (i.e. more than three individuals) are rare in South Australia. Those that have occurred are described below:

St Kilda (34°45'S, 128°32'E) September 1903

Hale (1931) described briefly the stranding of five *G. melaena* (= *melas*) now identified as *G. macrorhynchus*, in the mud of the St Kilda mangroves. A female stranded first (alive) followed by four males when the tide went out.

Port Prime (34°31'S, 138°18'E) approximately 5 October 1944

Hale (1945, 1959) described the mass stranding of about 250 *P. crassidens* in Gulf St Vincent, north of Adelaide. Approximately 200 stranded (some alive), along the coast of tidal flats in one group, with about 50 others stranding 2.5 km north of the main group and isolated individuals along a 30-km stretch of coast between Port Parham and Port Gawler. Very little biological data were collected or published on the stranded animals which were misidentified as *G. melaena* (= *melas*) at the time of stranding.

Merdayerrah/Eucla (31°41'S, 129°00'E) August 1963

In August 1963, about 59 *P. crassidens* stranded over about eight miles (= 13 km) of sandy beach between Merdayerrah Sandpatch, S.A. and Eucla, W.A. About 12 were on the sandpatch and 47 at Eucla. All were alive or freshly dead when found. Mr H. Gurney (pers. comm. 1989) believes that they stranded at high tide because there were furrows in the sand as if they had been driven up the beach. He recorded males, females and calves but did not count each category. The males were about 20–21 feet (6.4 m) in length and the calves (of varying length), a little less. According to Mr Gurney a storm did not precede the stranding.

TABLE 2. *Stranding events of* Tursiops truncatus *(a) and* Delphinus delphis *(b) which occurred inside and outside Gulf St Vincent and Spencer Gulf during four periods of the year.*

Location		Jan – Mar	Apr – June	July – Sept	Oct – Dec
(a)	Inside gulfs	9	3	4	2
	Outside gulfs	9	4	1	4
(b)	Inside gulfs	5	0	2	4
	Outside gulfs	7	3	2	4

TABLE 3. *South Australian cetacean stranding events involving more than one animal.*

Species	Number of individuals						
	2	3	5	14–17	55	60	c 250
Delphinus delphis	3		1				
Tursiops truncatus	1			1	1		
Mesoplodon sp.	1						
M. layardii	2	1					
Kogia breviceps	4						
K. simus	1						
Globicephala melas	2						
G. macrorhynchus			1				
Pseudorca crassidens						1	1

Memory Cove (34°58′S, 136°00′E) 2 May 1977

A school of 55 *T. truncatus* beached on the afternoon of 2 May at Memory Cove, 27 km southeast of Port Lincoln. Thirteen died and local authorities returned the remaining 42 to sea. Twelve of the dead were collected, measured and lodged in the South Australian Museum. Total lengths were 2.29 m – 3.10 m (6 ♀♀, 6 ♂♂). None had food in the stomach and one small male showed evidence of a recent shark attack on his side.

An unsubstantiated report of about 100 dolphins beaching themselves at Louth Bay, 45 km north of Memory Cove on the night of 3 May 1977 was found in P. Aitken's field notes (held in the SAM). Apparently three of these animals died.

American River, Kangaroo Island (35°47′S, 137°46′E) before 22 December 1982

Five male *D. delphis*, were found on a rocky beach at American River. Photographs of these animals indicate that they had been dead for a few days when found. American River is at the entrance to Pelican Lagoon, a shallow body of water with a rather restricted entrance. At least five other cetacean strandings have occurred there.

De Mole River, Kangaroo Island (35°42′40″S, 136°46′40″E) 27 April 1985

Between 14 and 17 *T. truncatus* stranded at Snug Cove at the mouth of the De Mole River, on the northwest coast of Kangaroo Island. The sandy beach (200 m wide) and river mouth are very small and form a shallow depression in the cliff-lined coast. The stranding was recorded by a local resident who observed a group of about 80–100 *T. truncatus* swimming offshore at about the time that the stranding occurred. One animal swam in the area for three days after the event. Most stranded animals were about 8–9 feet (2.4–2.7 m) long (D. Seikman pers. comm. 1987).

Age of stranded animals

Overall, 28% of the stranded cetaceans were juvenile, but there was great variation between certain species or species groups. Those having high proportions (>30%) of juveniles were *B. acutorostrata*, *C. marginata*, *Globicephala* spp., other Balaenopteridae and *Kogia* spp. (Table 4). Juvenile *B. acutorostrata* ranged from 3.23–3.96 m (approximately the size at weaning, Jonsgård 1951). Only one physically mature *B. acutorostrata* (9.13 m) and one neonate (2.3 m in October) were recorded. Length at birth has been estimated at about 2 m in *C. marginata*, based on the discovery of what was believed to have been a full-term foetus (McManus *et al.* 1984). Two neonates (2.01 m, which accords with this finding, and 2.10 m) have been recorded in South Australia, both in October (Fig. 11). About 40% of the measured *C. marginata* were roughly half maximum size (6.4 m).

Ziphiids had a low proportion of juveniles (14%), including a neonatal *M. grayi* (2.10 m) that stranded in December (Fig. 10). A stranded neonatal *E. australis* (5.52 m) was found in October. Its state of decomposition suggests it had been dead at least one month and could have been dead for up to four months based on the known calving season for this species in the area (Ling unpublished data). Only 9% of stranded *T. truncatus* were juveniles (Table 4).

TABLE 4. *Relative age of stranded cetaceans in South Australia. Species with insufficient numbers of individuals not included. See text for definition of juvenile length. N = number of individuals for which length recorded.*

Species	N	% Juvenile
Balaenoptera acutorostrata	10	90
Caperea marginata	16	56
Globicephala spp.	17	35
Other Balaenopteridae	12	33
Kogia spp.	14	31
Delphinus delphis	17	18
Ziphiidae	35	14
Tursiops truncatus	32	9

Active and passive strandings

At least 15% of the recorded stranding events involved live animals (active strandings). In many older stranding records it was not noted whether animals were dead or alive at the time of stranding, so this figure must be considered as minimal. Since 70% of the reported active strandings were after 1970, it is quite likely that more thorough investigations of future strandings (as have been the case in recent years) will result in a higher proportion being recorded as active. Sixteen species, representing all four families occurring in South Australia, are known to have stranded alive (Table 5). Only obviously moribund or decomposed animals were classed as passive stranders and therefore this proportion (6%) of the total number of events is liable to be an underestimate (Table 5). Decomposed carcasses found in remote areas were not added to the passive list unless observers mentioned the carcass having washed up at the time. There was a disproportionate number of large species (e.g. the large mysticetes and *P. macrocephalus*) in this category. (See also Fig. 2 for geographic location of active and passive stranding events.)

TABLE 5. *Cetacean stranding events involving live (active) and obviously dead (passive) cetaceans in South Australia.*

Species	Number of events Active	Passive
Eubalaena australis	0	1
Caperea marginata	2	5
Balaenoptera acutorostrata	3	0
B. edeni	2	0
B. musculus	0	2
Megaptera novaeangliae	0	2
Delphinus delphis	9	0
Globicephala macrorhynchus	3	0
G. melas	1	0
Grampus griseus	1	0
Pseudorca crassidens	1	0
Tursiops truncatus	7	0
Kogia breviceps	3	0
K. simus	1	0
Physeter macrocephalus	3	7
Berardius arnuxii	1	0
Hyperoodon planifrons	1	1
Mesoplodon sp.	1	0
M. grayi	1	0
M. layardii	5	0
Unidentified large whale	0	1
Totals	41	17

Discussion

Twenty-five cetacean species have stranded in South Australia. This includes *Mesoplodon hectori* recorded in February 1990 from the Coorong but not the doubtful *B. borealis*. One other species, *Mesoplodon mirus*, has been reportedly sighted (live) in South Australian waters, but without a specimen or photograph to confirm the identity of such a difficult group, the beaked whales, we cannot include this in the State's cetacean fauna. From 19 to 29 species have stranded or are known to occur in other states (Bryden 1978; Paterson 1986; Nicol 1987; Warneke 1988; L. Gibson pers. comm. 1990; J. Bannister pers. comm. 1990). Western Australia has the highest number of species, no doubt because its long coastline includes tropical and temperate waters. South Australia has the next highest, but lacks the tropical dolphins found in Queensland, Western Australian and occasionally New South Wales waters. Australia's cetacean fauna bears a resemblance to that of the southeast coast of southern Africa (Ross 1984). In terms of species composition and in some respects relative abundances in the stranding record, the situation in South Australia is most similar to Victoria and Tasmania. The major differences are many more *C. marginata* and beaked whale (especially *M. layardii*) events in South Australia than in Victoria; and fewer *G. melas*, *P. crassidens* and *Z. cavirostris*, but more *H. planifrons* than in Tasmania. The seventh most frequent strander in South Australia, *K. breviceps*, has not been recorded in Tasmania (Nicol 1987).

The species which occur in South Australia are either cosmopolitan, tropical/subtropical, temperate/subAntarctic or mixed-water in their distribution patterns (Ross 1984). Only *B. edeni* and *G. macrorhynchus* are considered to be tropical/subtropical in nature. The cool waters (15–18°C annual mean) in South Australia would not be expected to support a tropical fauna. However, Gulf St Vincent and Spencer Gulf are appreciably warmer than the waters off the seaward coast in summer. Also, the tropical Leeuwin current, which originates in autumn in the Indian Ocean and dissipates in winter in South Australia, may mix with warm Bight waters and move eastward (Rochford 1986).

All four reliably recorded stranding events of *B. edeni* occurred well within the gulfs (Fig. 6) during April (2), September (1) and November (1). *Balaenoptera edeni* occurs off Western Australia (Chittleborough 1959), but since no sightings of live *B. edeni* have been recorded in South Australia (J. K. Ling unpublished data), it is not known whether this species is resident in the gulfs or simply an occasional visitor. *Globicephala macrorhynchus*

has stranded during the winter months inside and outside the gulfs. We suggest that the presence of these species and the frequent strandings and sightings of turtles (A. Edwards pers. comm. 1989) could be related to the Leeuwin current and the warm gulf waters. Zeidler (1989) has suggested that the Leeuwin current may have been responsible for tropical octopus occasionally being recorded in South Australia.

Sergeant (1979) concluded that abundance in the stranding record in most cases reflects the abundance of the free-living population in a particular region. Mead (1979) suggested that *K. breviceps* might be an exception. Other comparable examples are *O. orca*, which occurs in eastern and southern Australia but rarely strands (Bryden 1978; Warneke 1988; Ling 1991; present study), and *E. australis*, which is sighted frequently in coastal waters but also rarely strands. Only five verified strandings of *E. australis* have been reported in South Australia, Victoria and Tasmania (Warneke 1988; present study).

If the stranding record reflects abundance, species that stranded on only one or two occasions (Table 1) may be designated as rare or occasional visitors to South Australian waters. Hence *B. physalus, P. crassidens, K. simus, B. arnuxii, M. hectori, M. bowdoini, T. shepherdi* and *Z. cavirostris* are probably rare here, at least in shallow (< 200 m) waters between the continental shelf and the coast. Deep-water and pelagic species such as *P. crassidens* and *Z. cavirostris* (Leatherwood & Reeves 1983; Ross 1984) are frequent stranders in Tasmania (Nicol 1987) and New Zealand (Baker 1983), where deep waters occur closer to shore than in South Australia. The same may apply to *T. shepherdi*: a more common stranded in New Zealand (A. Baker pers. comm. 1990) than in Australia. Beaked whales tend to live in deep waters (>200 m) beyond the continental shelf where they feed on deep-water fishes and squid (Ross 1989). They may also feed in areas having underwater canyons (G. Ross pers. comm. 1990) such as the Murray Canyons, southeast of Kangaroo Island, and the canyons southwest of Ceduna (Griffin & McCaskill 1986).

Whether cetacean strandings happen (or are recorded) depends upon many factors including animal movements (seasonal or diurnal), human activity and awareness, the physical environment and the climate. In Tasmania, Nicol (1986) found that cetacean strandings were recorded most frequently in regions with high human activity and a complex coastline. Geraci & St Aubin (1979) concluded that most strandings occur on gently sloping beaches or natural 'traps' in the shoreline.

In South Australia, reported stranding events do not occur evenly along the coast (Fig. 1). They were frequent in regions with large bays (e.g. Coffin Bay/Port Lincoln, Nepean Bay, Streaky Bay) and along westward and southwestward facing coasts (e.g. Coorong, and eastern gulf shores). Observer effort may partly explain these concentrations of reports, because several areas of frequently reported strandings are near cities or are popular with holidaymakers. Reduced observer effort, however, does not account for the small number of reports from the western side of Gulf St Vincent and probably not Spencer Gulf. We believe that prevailing southwesterly winds in winter and spring may contribute to the frequency of strandings along eastern shores (see Fig. 1). Other studies have suggested that adverse weather is associated with strandings (Duguy 1978), but there are few substantiating data (Geraci & St Aubin 1979).

Another important reason for the trends may be that strandings are more frequent where cetacean abundance is high (Sergeant 1979). Presumably abundance is high because productivity of the marine environment is high in some areas, such as where upwelling events occur or deep sea canyons are part of the bottom topography. Upwellings are common summer features in the southeast of South Australia (Lewis 1981; Rochford 1986) and along the coast north of Coffin Bay (P. Petrusiviez pers. comm. 1990). Canyons occur from Kangaroo Island to the Victorian border and in the Great Australian Bight. Some of the areas of high stranding frequency (Fig. 1) can be explained by these oceanographic features.

In South Australia, cetacean stranding events were recorded throughout the year (Fig. 9) with two peaks in frequency: summer and early autumn (January – April), and early spring (September and October). Observer effort would be expected to increase during the summer months, when people spend more time on the beaches and are likely to find stranded animals. Nicol (1986) found that the highest number of strandings in Tasmania was recorded in January and that the winter months of July and August had fewer recorded events. Warneke (1988) also noted that in southeastern Australia more strandings were recorded in summer than in winter. One would expect that in South Australia the stranding frequency of the known migratory species, generally the baleen whales, would increase in winter, but it was spring when many stranded (Fig. 11). It is noteworthy that many of the rorquals that stranded in spring were *B. acutorostrata*, most of which were the size of animals at weaning. Rorquals were absent from the Tasmanian stranding record during the summer months (Nicol 1986).

The early spring peak in the overall record (Fig. 9) cannot be explained by observer effort alone;

wind may be an important factor. Wind velocity and frequency, illustrated in the form of wind roses in the Climatic Atlas of Australia (1988), show an increase in the October quarter for much of coastal South Australia, and coming from a southwesterly direction onto the coast.

Mass strandings are events restricted to the odontocetes (Sergeant 1982) and are most frequently recorded in *Globicephala* spp., *P. crassidens*, *Lagenorhynchus acutus* and *P. macrocephalus* (Geraci & St Aubin 1979). These are highly social and oceanic species. Mass strandings generally occur where a species is abundant (Sergeant 1982). It is therefore not surprising to find that in South Australia, where shallow waters extend far off the coast and oceanic species would not be expected to occur in large numbers, there have been only six recorded mass stranding events. A similar picture is true for Victoria (seven events: Warneke 1988) and Queensland (two events: Paterson 1986), both with wide continental shelfs. The low number (six; L. Gibson pers. comm. 1990) of mass strandings in New South Wales where waters are deep, may be a reflection of the relatively uncomplicated nature of the coast. In South Australia the species which have mass stranded are *P. crassidens*, *G. macrorhynchus*, *T. truncatus* and *D. delphis*.

Overall, the percentage of juveniles which stranded was rather high (28%), a trend also noted by Duguy (1978) in France. Sergeant (1982) concluded that odontocetes have a lower juvenile mortality than mysticetes, probably because of the greater parental care generally associated with odontocete social structure. The present study confirms this, e.g. high juvenile proportions of *C. marginata* and *B. acutorostrata*, but some odontocetes also had about a third juveniles (Table 4). Sergeant (1982) reported that newly weaned and old *B. acutorostrata* strand selectively. In South Australia young *B. acutorostrata*, 3.23–3.96 m in length, have stranded between the months of August and October. This is slightly less than the estimated length at weaning (4.5 m) reported by Lockyer (1984). Births in *B. acutorostrata* in the southern hemisphere are reported to occur in May and June (Lockyer 1984), but in our records one neonatal animal of 2.3 m stranded in South Australia in late September or early October. The body lengths of stranded *C. marginata* (2.01–6.20 m) are more evenly distributed than *B. acutorostrata*, but there is also a tendency for animals to be about the estimated length (*ca* 3.2–3.6 m) at weaning (Ross *et al.* 1975).

In the eastern United States, 17% of the cetacean stranding events involved live animals (Mead 1979). All species with a high incidence of active stranding were offshore forms. *Physeter macrocephalus*, a deep water species, most commonly stranded alive, in contrast to the situation in South Australia and other places (Rice 1989), where single animals are usually dead or moribund. In South Australia, at least 15% of the recorded strandings were active, but recent information suggests a much higher percentage.

The South Australian marine environment is unique: low nutrient levels are offset by upwelling events and proximity to the rich waters south of the Antarctic Convergence; the Indian Ocean influences the oceanographic conditions through several currents; and the gulf waters afford some protection from wind and cold water, at least at some times of year.

It is hoped that additions to the cetacean stranding data base, coupled with a better insight to the State's oceanography, will permit more detailed analysis of the trends identified here and lead to a greater understanding of the biology of the many species of whales that occur in southern Australian waters.

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